

New Atmospheric Compound Tied to Climate Change, Human Health

ScienceDaily (Aug. 8, 2012) — An international research team led by the University of Colorado Boulder and the University of Helsinki has discovered a surprising new chemical compound in Earth's atmosphere that reacts with sulfur dioxide to form sulfuric acid, which is known to have significant impacts on climate and health.

The new compound, a type of carbonyl oxide, is formed from the reaction of ozone with alkenes, which are a family of hydrocarbons with both natural and human-made sources, said Roy "Lee" Mauldin III, a research associate in CU-Boulder's atmospheric and oceanic sciences department and lead study author. The study charts a previously unknown chemical pathway for the formation of sulfuric acid, which can result both in increased acid rain and cloud formation as well as negative respiratory effects on humans.

"We have discovered a new and important, atmospherically relevant oxidant," said Mauldin. "Sulfuric acid plays an essential role in Earth's atmosphere, from the ecological impacts of acid precipitation to the formation of new aerosol particles, which have significant climatic and health effects. Our findings demonstrate a newly observed connection between the biosphere and atmospheric chemistry."

A paper on the subject is being published in the Aug. 9 issue of *Nature*.

Typically the formation of sulfuric acid in the atmosphere occurs via the reaction between the hydroxyl radical OH -- which consists of a hydrogen atom and an oxygen atom with unpaired electrons that make it highly reactive -- and sulfur dioxide, Mauldin said. The trigger for the reactions to produce sulfuric acid is sunlight, which acts as a "match" to ignite the chemical process, he said.

But Mauldin and his colleagues had suspicions that there were other processes at work when they began detecting sulfuric acid at night, particularly in forests in Finland -- where much of the research took place -- when the sun wasn't present to catalyze the reaction. "There were a number of instances when we detected sulfuric acid and wondered where it was coming from," he said.

In the laboratory, Mauldin and his colleagues combined ozone -- which is ubiquitous in the atmosphere -- with sulfur dioxide and various alkenes in a gas-analyzing instrument known as a mass spectrometer hooked up with a "flow tube" used to add gases. "Suddenly we saw huge amounts of sulfuric acid being formed," he said.



Lake and forests in Finland. (Credit: © chaos / Fotolia)

Because the researchers wanted to be sure the hydroxyl radical OH was not reacting with the sulfur dioxide to make sulfuric acid, they added in an OH "scavenger" compound to remove any traces of it. Later, one of the research team members held up freshly broken tree branches to the flow tube, exposing hydrocarbons known as isoprene and alpha-pinene -- types of alkenes commonly found in trees and which are responsible for the fresh pine tree scent.

"It was such a simple little test," said Mauldin. "But the sulfuric acid levels went through the roof. It was something we knew that nobody had ever seen before."

Mauldin said the new chemical pathway for sulfuric acid formation is of interest to climate change researchers because the vast majority of sulfur dioxide is produced by fossil fuel combustion at power plants. "With emissions of sulfur dioxide, the precursor of sulfuric acid, expected to rise globally in the future, this new pathway will affect the atmospheric sulfur cycle," he said.

According to the U.S. Environmental Protection Agency, more than 90 percent of sulfur dioxide emissions are from fossil fuel combustion at power plants and other industrial facilities. Other sulfur sources include volcanoes and even ocean phytoplankton. It has long been known that when sulfur dioxide reacts with OH, it produces sulfuric acid that can form acid rain, shown to be harmful to terrestrial and aquatic life on Earth.

Airborne sulfuric acid particles -- which form in a wide variety of sizes -- play the main role in the formation of clouds, which can have a cooling effect on the atmosphere, he said. Smaller particles near the planet's surface have been shown to cause respiratory problems in humans.

Mauldin said the newly discovered oxidant might help explain recent studies that have shown large parts of the southeastern United States might have cooled slightly over the past century. Particulates from sulfuric acid over the forests there may be forming more clouds than normal, cooling the region by reflecting sunlight back to space.

Most of the laboratory experiments for the study were conducted at the Leibniz-Institute for Tropospheric Research in Leipzig, Germany.

Co-authors on the study include Torsten Berndt and Frank Stratmann from the Leibniz-Institute for Tropospheric Research; Mikko Sipilä, Pauli Paasonen, Tuukka Petäjä, Theo Kurtén, Veli-Matti Kerminen and Markku Kulmala from the University of Helsinki in Finland; and Saewung Kim from the National Center for Atmospheric Research in Boulder. Mauldin also is affiliated with NCAR and the University of Helsinki.

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